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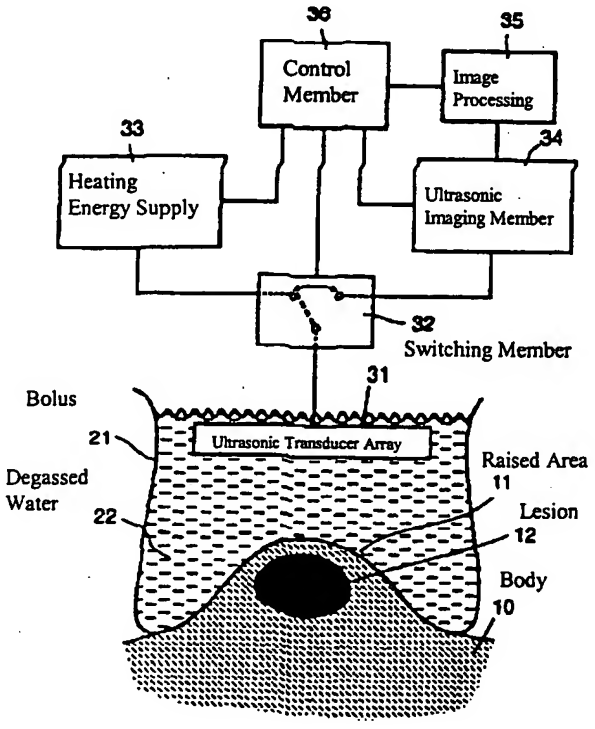
(54) [Title of the Invention] **ULTRASONIC HYPERTHERMIA APPARATUS**

(57) [Abstract]

STATEMENT OF PROBLEM: To perform thermal treatment of a lesion underlying a raised area of the body while preventing damage to normal tissues.

SOLUTION: This apparatus is provided with an ultrasonic transducer array 31 to be arranged facing a lesion 12 underlying a raised area of the body 11, a heating energy supply member 33 and an ultrasonic imaging member 34 which are connected to the array 31 through a switching member 32, an image processing member 35 which processes an ultrasonic image to distinguish the lesion 12 from normal tissue, and a control member 36 to control the heating energy supply member 33 based on data obtained thereby concerning the lesion 12.



[Claims]

[Claim 1] An ultrasonic hyperthermia apparatus provided with a two-dimensional array of ultrasonic transducers that is positioned to face the raised area to be heated via an impedance matching liquid, a heating energy supply member that operates the transducer array and generates ultrasonic waves used for heating, an ultrasonic imaging member that operates the transducer array to generate ultrasonic search waves and processes the received signals of reflected waves received by the transducer array to obtain a reflected-wave intensity distribution image, a switching member that switches the transducer array between the heating energy supply member and the ultrasonic imaging member, an image processing member that detects the lesion underlying the raised area to be heated using the reflected wave intensity distribution image, and a control member that controls the switching member and also controls the heating energy supply member so that the ultrasonic waves for heating will be focused on the detected lesion.

DETAILED DESCRIPTION

[Detailed Description of the Invention]

[0001]

[Technical Field] This invention relates to the equipment which emits ultrasonic waves and performs hyperthermia treatment.

[0002]

[Prior Art] Hyperthermia equipment performs therapy by heating disease lesions, such as cancer, tumors and the like. Ultrasonic hyperthermia equipment utilizes ultrasonic waves as heating energy. That is, when ultrasonic waves irradiate a living body, the ultrasonic wave energy will be converted to heat in the tissues of the body, and that part of the body will be heated.

[0003] However, hyperthermia therapy must be performed so that only the lesion is heated and other normal tissues are not. When normal tissues are also heated, they may be burned or otherwise damaged.

[0004]

[Statement of the Problem] With prior art ultrasonic hyperthermia equipment there is a problem because heating cannot always be restricted to the lesion and there is a risk of inflicting damage to peripheral normal tissues.

[0005] In light of this situation, the object of the present invention is to provide an ultrasonic hyperthermia apparatus that treats only the lesion without damaging normal tissues by focusing the ultrasonic waves on a lesion underlying a raised area of the body, and this is accomplished by utilizing the fact that it is particularly easy to identify lesions such as cancer that underlie raised areas of the body by ultrasonic imaging and then focus the ultrasonic waves on those lesions.

[0006]

[Solution to the Problem] In order to realize the above object, the inventive ultrasonic hyperthermia apparatus is characterized by the fact that it provides a two-dimensional array of ultrasonic transducers that is positioned to face the raised area to be heated via an impedance matching liquid, a heating energy supply member that operates the transducer array and generates ultrasonic waves used for heating, an ultrasonic imaging member that operates the transducer array to generate ultrasonic search waves and processes the received signals of reflected waves received by the transducer array to obtain a reflected-wave intensity distribution image, a switching member that switches the transducer array between the heating energy supply member and the ultrasonic imaging member, an image processing member that detects the lesion underlying the raised area to be heated using the reflected wave intensity distribution image, and a control member that controls the switching member and also controls the heating energy supply member so that the ultrasonic waves for heating will be focused on the detected lesion.

[0007] It is easy to distinguish a lesion underlying a raised area from normal tissue based on its ultrasonic image. If a lesion underlies a raised area, it is easy to focus the ultrasonic heating waves on that lesion. Therefore, heating therapy of the lesion is performed by positioning a two-dimensional array of ultrasonic transducers to face the lesion via an impedance matching liquid, obtaining an ultrasonic image using this transducer array, identifying the lesion from this image, and controlling the heating energy supply member so that the ultrasonic heating waves are focused on the lesion, and when the lesion underlies a raised area, heating only the lesion without heating the normal tissue, thus preventing damage to the normal tissue.

[0008]

[Embodiment of the Invention] A detailed description of an embodiment of the invention follows with reference to the drawing. In Figure 1, the lesion 12 underlies a raised area 11 of the body (patient's body) 10. A bolus (flexible water bag) 21 is applied to the surface of the raised area 11. The bolus 21 is filled with degassed water 22. A two-dimensional array of ultrasonic transducers 31 is positioned within the degassed water 22, and ultrasonic waves from this ultrasonic transducer array 31 irradiate the body 10 via the degassed water 22. The degassed water 22 functions as an impedance matching liquid with respect to the ultrasonic waves between the ultrasonic transducer array 31 and the body 10.

[0009] A heating energy supply member 33 and an ultrasonic imaging member 34 are connected to the ultrasonic transducer array 31 via a switching member 32. The heating energy supply member 33 supplies the ultrasonic transducer array 31 with a high power drive signal, high energy ultrasonic wave vibrations are generated by the ultrasonic wave transducer array 31 that was activated by this signal, and the body 10 is heated.

[0010] The ultrasonic imaging member 34 activates the ultrasonic transducer array 31 to generate a combined ultrasonic search wave. The amplitude and phase of the drive signal supplying each element of the ultrasonic transducer array 31 is controlled to shape the combined ultrasonic search wave into a narrow beam. When the ultrasonic search waves penetrate the body 10 the tissues in the body 10 reflect them, and the reflected

waves return to the ultrasonic transducer array 31 where they are received. By controlling the phase of the wave reception signals from each element of the ultrasonic transducer array 31 and the like, a reflected wave intensity (received ultrasonic wave beam) is obtained for each portion of the narrow field corresponding to the transmitted ultrasonic wave beam. The transmitted and received ultrasonic wave beams are scanned, and a reflected wave intensity distribution is obtained for a certain cross-section.

[0011] This reflected wave intensity-distribution image is sent to the image-processing member 35, and image processing for detecting the lesion 12 is made. When they lie deep within the body 10, it is difficult to distinguish lesions 12 such as cancer and the like from tissues having various wave reflection intensities such as organs and the like, but when lesions underlie raised areas 11, the reflected wave intensity is different, being stronger (or sometimes weaker) than surrounding tissues, and it is easy to distinguish lesions from the surrounding tissue. Therefore, it is possible to detect lesions 12 in the image processing member 35 by establishing a suitable threshold value and performing threshold value processing of the image.

[0012] When the position and size of the lesion 12 is detected in this manner, this data is sent to the control member 36, and the control member 36 controls the heating energy supply member 33 using that data. As a result, the phase and amplitude of the drive signal that supplies each element of the ultrasonic wave transducer array 31 are adjusted, and a combined ultrasonic wave is generated that is focused on the lesion 12. At that time, the switching member 32 is switched to the heating energy supply member 33 under the control of the control member 36.

[0013] In this manner it is possible to focus the heating energy on the lesion 12 underlying the raised area 11 and heat only the lesion 12. Because the lesion 12 lies within the raised area 11, it is easy to control the heating energy so that it is focused on the lesion, and thus it is possible to prevent normal tissue from being damaged by excessive heating because the normal tissue is not heated.

[0014] Furthermore, in the above description the image processing member 35 performs threshold value imaging of the ultrasonic image obtained from ultrasonic imaging member 34, the lesion 12 is detected automatically, and the heating energy supply member 33 is controlled in response to that, but it is also possible to display the ultrasonic image on a suitable monitor in the form of a graphic display, and an operator such as a physician can distinguish the lesion 12 by observing the image and manually set the field to be heated by operating a mouse and the like. Moreover, because the reflection coefficient with respect to ultrasonic waves changes with changes in temperature, it is possible to utilize this function to convert an ultrasonic image to a temperature distribution image. More specifically, during the heating process it is possible to switch the switching member 32 to the ultrasonic imaging member 34, quickly obtain an ultrasonic image by transmitting and receiving ultrasonic waves, and converting that image to a temperature distribution image. Thus it will be possible to perform ultrasonic wave irradiation to achieve optimal temperature distribution by having the control member 36 control the heating energy supply member 33 based on this temperature distribution image.

[0015]

[Advantage of the Invention] As described above, with the inventive ultrasonic hyperthermia apparatus it is possible to perform therapy that treats only the lesion without damaging normal tissues by focusing the ultrasonic waves on a lesion underlying a raised area of the body, and this is accomplished by utilizing the fact that it is particularly easy to identify lesions such as cancer underlying raised areas of the body by ultrasonic imaging and then focus the ultrasonic waves on those lesions.

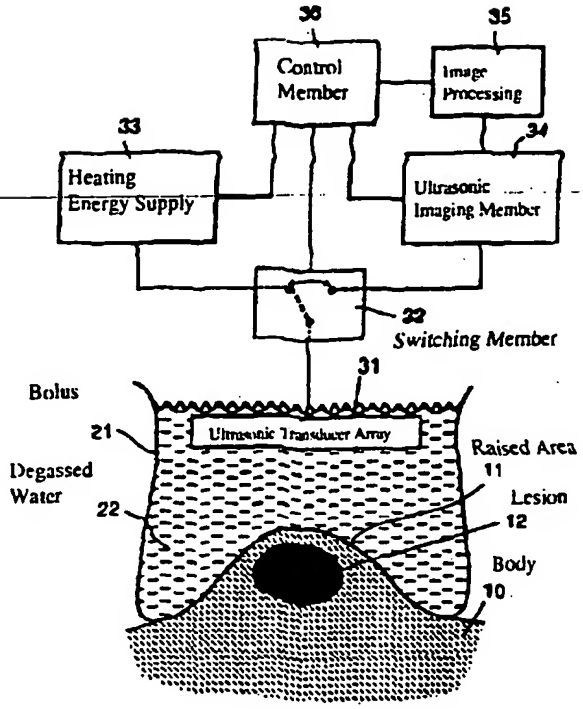
[Brief Description of the Drawings]

[Figure 1] This figure shows a block diagram of the embodiment of this invention.

[Explanation of Key]

| | |
|---|---|
| 10 | Body |
| 11 | Raised Area |
| 12 | Lesion |
| 21 | Bolus |
| 22 | Degassed Water |
| 31 | Ultrasonic Transducer Array |
| 32 | Switching Member |
| 33 | Heating Energy Supply Member |
| 34 | Ultrasonic Imaging Member |
| 35 | Image Processing |
| 36 | Control Member |

[Figure 1]


36
Control Member
35
Image Processing
33
Heating Energy Supply
34
Ultrasonic Imaging Member
32
Switching Member
31
Bolus
21
Ultrasonic Transducer Array
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11
Degassed Water
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Lesion
12
Body
10